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ON SPECTACLE LENSES OF ASYMMETRICAL CURVATURE.

BY JOHN GREEN, M. D., ST. LOUIS.

As astigmatism, whether simple, compound or mixed, may be reduced, as an optical error, to terms of asymmetrical refraction at the anterior surface of the cornea, so its correction would naturally be sought in a lens with a surface of correspondingly asymmetrical curvature. In the case of simple hypermetropic or myopic astigmatism, this condition is fulfilled by a convex or concave cylindrical lens, and in compound and mixed astigmatism we similarly prescribe a lens combining a cylindrical surface, to equalize the refraction of the eye in its two principal meridians, with a spherical surface of such radius as may be required to correct the remaining ametropia. By these combinations, which have been adopted on account of especial convenience and consequent economy in manufacture, we obtain lenses of asymmetrical refraction, whose meridians of greatest and least refraction are determined by the direction of the axis of the cylindrical surface.

In the presence of a relatively high grade of ametropia, we occasionally correct a relatively low grade of astigmatism by means of a spherical lens, of a focus determined by the measure of the (nearly horizontal) meridian of least ametropia, mounted somewhat obliquely to the direction of the axis of the eye. In

certain other cases in which a relatively low grade of astigmatism has been left uncorrected, the wearer similarly learns to improve his acuteness of vision by regulating the carriage of his head so as to enable him to look obliquely through his spherical glasses. The obliquely mounted spherical lens, like the lens ground with a spherical and a cylindrical surface, is practically equivalent to a lens of asymmetrical curvature with its meridian of greatest refraction at right angles to the axis about which the plane of the lens is rotated.

Concave lenses of asymmetrical curvature have been produced by glass-cutters, probably from the time of the first invention of their art. Examples of such lenses are seen in the polished punty mark which is ground in the bottom of decanters and drinking glasses, and in the shallow depressions with which glass-cutters are in the habit of studding the surface of lamp globes, and of decorating panes of ground glass which are intended to transmit light without permitting objects to be seen distinctly through them. These concave surfaces are ground upon a revolving wheel rounded at its periphery, and have the form of spherical segments whenever the radius of the curved periphery is exactly equal to the radius of the wheel. In all other cases the polished surface is of asymmetrical curvature, and when ground upon a flat plate of glass, forms a plano-concave lens of asymmetrical refraction, such as is required for the correction of a case of compound myopic astigmatism.

If such an asymmetrical depression is ground on one of the surfaces of an ordinary double-convex lens, whose opposite spherical surface is of the same radius of curvature as the radius either of the grinding wheel or of its curved periphery, the resultant lens will be the optical equivalent of either a concave or a convex plano-cylindrical lens, but it will be of the meniscus or periscopic form, with both its surfaces curved in all meridians. In like manner, the asymmetrical concave surface may be ground upon one side of either a double- or plano-convex, or a double- or plano-concave spherical lens, of any desired radius of curvature, and thus a concave or convex meniscus, or a double-concave lens, may be ground of any required refractive power in each of its principal meridians.

If we make the wheel hollow, and use the concavity of its periphery as the grinding surface, we may, similarly, produce lenses with an asymmetrical convex surface, and by grinding this asymmetrical surface upon one side of an ordinary double-convex lens we obtain a lens of asymmetrical refraction, of the double-convex form. [1]

If we groove the periphery of the grinding wheel so as to give to it the form of a pulley, the lens-surface ground upon it will be concave in the meridian corresponding to the plane of the wheel and convex in the other principal meridian. Such a lens approximates quite closely, in its optical properties, to a lens with crossed + and — cylindrical surfaces, or with a + or — spherical combined with a — or + cylindrical surface, such as is ordinarily prescribed in a case of mixed astigmatism.

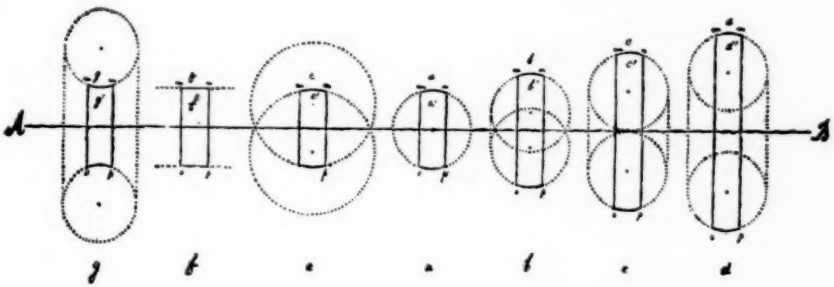

FIG. 6.

Figure 6, *a*, *b*, *c*, *d*, *e*, *f*, *g*, represents, in cross-section, a series of grinding wheels, *m n o p*, in which the radius either of the wheel or of its curved cutting periphery is taken of different values. If we represent the radius of the wheel by R and the radius of the cutting periphery by *r* we may take.

(*a*) R = *r*, in which case the periphery of the wheel will be an

1. Such a lens is practically equivalent to a double-convex lens with crossed cylindrical surfaces of unequal radii, and, inasmuch as the double-convex form yields lenses of the lightest possible weight, a double-convex lens of one or the other of these types may offer a certain advantage in the correction of astigmatism in the aphakial eye.

equatorial zone of a sphere, and the lens-surface ground upon will be a concave spherical segment; or

(a') $-R = -r$, in which case the lens-surface will be a convex spherical segment.

If, varying R, r remaining constant, we take

(b,c,d,) $R > r$, or (b', c', d',) $-R > -r$, the limiting form of the resultant figure of revolution will be an open ring (d, d'), and the lens-surfaces ground upon its peripheral zone will be either concave or convex, and of asymmetrical curvature.

If, varying r, R remaining constant, we take

(e) $r > R$, or (e') $-r > -R$, we obtain an ovoid figure of revolution with pointed ends (e), upon whose equatorial zone may be ground either a concave or a convex lens-surface of asymmetrical curvature, corresponding, in its two principal sections, to the radii of the grinding surface of the wheels, b, c, d.

If we take

(f) $r = \infty$, or (f') $-r = \infty$, the figure of revolution becomes a cylinder, and the lens-surfaces ground upon its outer and inner surface will be concave-cylindrical and convex-cylindrical respectively.

If

(g, g') we assume a negative value for r, the resultant figure of revolution will be concave in one of its principal sections and convex in the other, and the lens-surfaces ground upon its equatorial zone will similarly be convex in one principal section and concave in the other. These several grinding surfaces may be described as generated by the revolution of an arc of a circle about its chord, or about a line parallel to its chord, as an axis. The limiting form of a ring is reached when the arc is taken equal to 360°, or a whole circle, in which case the chord becomes a tangent (figure 1, e): when the axis of revolution is taken outside the circle an open ring is generated (figure 1, d).

Figure 7, which represents an open ring in its cross and median sections shows the several forms of asymmetrical grinding surfaces, as given in figure 1, b, c, d, g and b', c', d', g', and also the two principal sections of each of the lens-surfaces ground upon them. These principal sections are, by the conditions of the construction, arcs of circles with R and r as radii, and the inter-

mediate sections, in the cases b, c, d, and b', c', d', may be roughly considered as small arcs of circles with radii less than R and

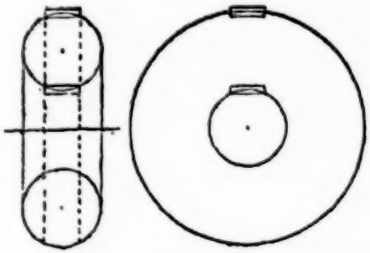

FIG. 7.

greater than r.* In the case g, g', the two principal sections are circular arcs, of which the one is convex and the other concave, and somewhere between these are two other sections which may be considered as practically straight lines.† All sections intermediate between these and the two principal sections may be roughly considered as small arcs of circles, with radii varying on the one hand between the limits ∞ and R,‡ and on the other hand between the limits ∞ and $-r$.§

In the case (*e*) $r >$ R or (*e'*) $-r > -$ R, as in the cases b, c, d and b',c',d', the two principal sections of the grinding surface are arcs of circles with R and r as radii, but the intermediate sections, which may be roughly described as small arcs of circles with radii less than r and greater than R, are really curves of a different form from the oblique sections of the ring.¶

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* This statement is true only in the qualified sense that any very small arc may, without important error, be considered as equivalent to an arc of some circle. If the curved periphery of the wheel is taken as an

FIG. 8.

equatorial zone of an oblate ellipsoid (figure 8), all sections by planes perpendicular to the axis will be circles, and all other plane sections will be ellipses or arcs of ellipses.

At the annual meeting of the American Ophthalmological Society, July 15–16, 1885,[1] Dr. G. C. Harlan exhibited a number of lenses with surfaces of asymmetrical curvature ground upon tools corresponding in form to a small peripheral segment of a wheel, as shown in section in figure 1, *b*, *c*, *d*, and perhaps *e*. These lenses, from the work-shop of Mr. I. L. Borsch, of Philadelphia, were ground by an oscillating motion of the tool or of the lens about the line A B as an axis. Such lens-surfaces represent very nearly the optical equivalent of the different combinations of a concave- or convex-cylindrical with a concave- or convex-spherical surface, and, when ground upon one side of an ordinary

† This condition will be exactly fulfilled if the pulley surface is taken as a hyperboloid of revolution of one sheet (figure 9). ‡ The sections

FIG. 9.

intermediate between these straight lines and the equatorial section of the wheel will then be arcs of ellipses, ‡ and the other sections will be hyperbolas.

¶ If the grinding periphery of the wheel is taken as an equatorial zone of a prolate ellipsoid (figure 10), all sections by planes perpendicular

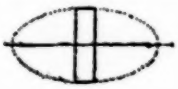

FIG. 10.

to the axis will be circles and all other plane sections will be ellipses or arcs of ellipses.

For an analysis of the oblique sections of the open ring, shown in its principal sections in figure 2, I am indebted to the kindess of Professor E. A. Engler, of Washington University; of these sections two are *lemniscates*, and the others are either *ovals of Cassini* or other ovals not ellipses.

1. Transactions of the American Ophthalmological Society, 1885, page 96.

double-convex lens, may yield lenses equivalent to either a concave or convex-cylindrical lens or to any required combination of a cylindrical with a spherical surface. As now manufactured, these lenses can be furnished only at a cost considerably greater than that of the ordinary spherico-cylindrical combinations, over which they appear to offer no very important advantage.[1] Should any considerable demand arise for such lenses it will doubtless prove more economical to grind them upon revolving wheels, rather than upon the small tools used by Mr. Borsch. They may then be manufactured in large quantities and kept in stock, as is now the case with plano-cylindrical lenses, leaving the formula to be completed by the addition of any required spherical surface. At the very least, the number of different values of r to be provided must be equal to the series of plano-cylindrical glasses as now manufactured, and this number must be multiplied several fold in order to provide for the minimum number of required values of R.

It would seem hardly necessary to repeat the elementary proposition that the formula for any combination of two cylindrical surfaces may always be reduced to an equivalent formula in terms of one cylindrical and one spherical surface. Two cylindrical surfaces with crossed axes need, therefore, never be prescribed, unless for some reason wholly independent of optical requirements; still less need we ever demand of the optician to grind two cylindrical surfaces with axes of any other inclination to each other than 90°, even though such a combination may have been arrived at empirically, as the result of experimental testings with the Stokes lens or with casual combinations of plano-cylindrical trial-glasses.

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1. The possibility of making these lenses of the meniscus or periscopic form admits of certain minor refinements, in special cases, not always so perfectly attainable by combinations of a convex or concave spherical, with a concave or convex cylindrical surface, or of plus and minus cylindrical surfaces with crossed axes. *cf.* note on page 55.

SCINTILLATING SCOTOMA (AMAUROSIS PARTIALIS FUGAX) AS EXPERIENCED BY THE WRITER.

BY ADOLF ALT, M. D.

Scintillating scotoma has before this been carefully described by authors who themselves had experienced it (Wollaston, Listing, Vater, and Heinicke and others) yet I am in the position to add to theirs one more observation, of which I was object and subject at the same time, and I think its description may be of interest as the affection is a comparatively rare one.

There seems to be no doubt but that this affection is a purely

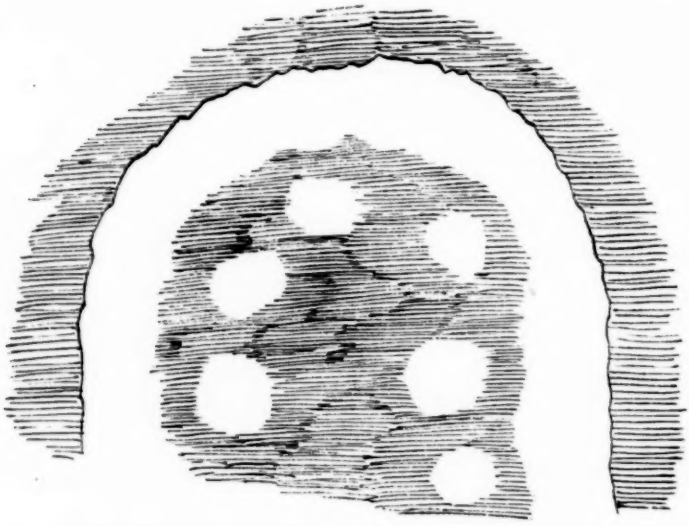

FIG. 11.

nervous one which, as a rule, passes off without any consequences of any importance. Leber states that it is so frequently combined with nervous headache, that he has no doubt the two affections belong intimately together.

Some three weeks ago having become rather anæmic, and generally low in my constitution by continued indigestion and

diarrhea, mental labor and worry, I drove on a sunny morning down to my office. The ground was covered with snow. Presently I saw on the back of my horse and to the left of him a bright yellowish semicircle, rather resembling a horse shoe, and inside of it a number of yellowish bright spots arranged almost like the nails belonging to this horse shoe (see figure 11). I thought at first that the reflex from the snow had caused this appearance; but wherever I looked there it was before me, apparently about five feet distant and to the left of the fixation point, but not touching the latter, and it was the same whether I shut one eye or both. About five minutes after first noticing

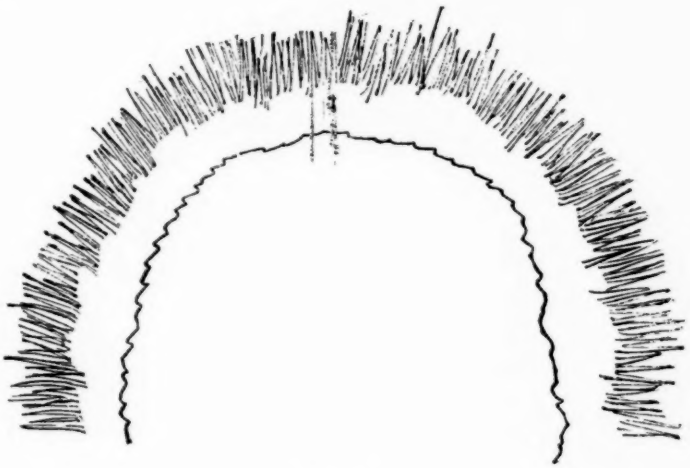

FIG. 12.

the bright semicircle, I reached my office. At once testing my vision I found that the picture was changed The semicircle was now somewhat smaller, the bright points inside of it were gone, and its outer periphery was varying continually, apparently consisting of shooting rays of light in uninterrupted motion. They were of various colors, but yellow and blue were predominating.

I have tried to give an idea of this condition in figure 12. My vision was now reduced to $\frac{20}{L}$, and when I looked at the test card the letters seemed in continued motion and crowded from the

right to the left. I began now to feel so weak that I gave up observation for a time, and waited patiently for the effect which several doses of sherry would have on my condition. After about five minutes I began to feel stronger again and then found the picture changed once more. The semicircle was larger and its periphery instead of consisting of shooting rays altogether, had a crenated appearance like the battlements of an old fortress, only here and there some shooting rays would yet appear; and and this crenated outline also changed its shape continually.

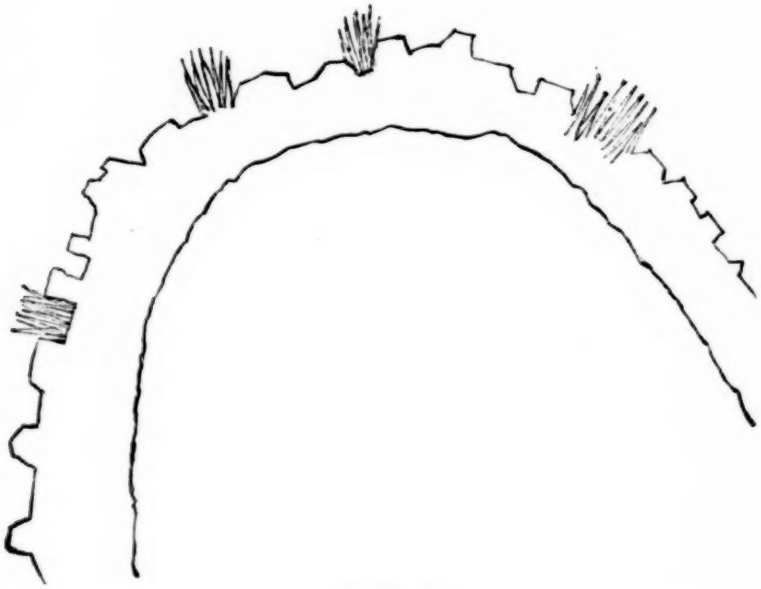

FIG. 13.

(See figure 13.) From this on the circle grew larger and larger, the continued motion became more and more reduced, the brightness seemed to fade away and finally was gone. The whole attack lasted about from 25 to 30 minutes. My head felt a little dull after it, but this may have been and probably was due to the sherry. I have never had any similar affection before, nor since.

The center of the visual field was evidently but slightly affected, and the scotoma lay throughout the attack somewhat to the left

of it. It was, moreover, as I stated before, from the beginning observed in both eyes, and in the same portion of the visual field in either eye.

It may not be out of place to give here a few of the remarks made by Leber (Græfe & Saemisch, v. 2, p. 944, etc.) on this affection. He says:

"The center of the visual field is usually left free during these attacks, but it may be affected also.

"In the hemianopic form (in some cases a pure hemianopia has been observed) different halves of the visual fields may be attacked during different attacks.

In most cases both eyes are affected, and this is, perhaps, al ways the case. Although several observers state that one eye only had been affected, or that the second one was affected later than the first, this point is very difficult to settle. Good observers confess that they could not make out clearly whether the affection was monocular or binocular, because it continued even when the eyes were closed. Yet the central location of the affection, which can hardly be doubted, supports the opinion that it is always binocular, although the possibility of a purely monocular central disturbance of vision can, as yet, not be denied with certainty.

Most observers state the duration of the attack to be about half an hour; but it may vary between a few minutes and several hours. * * * * *

The frequency of the attacks varies considerably. Some individuals have only one or a few attacks during their life; with others they are repeated oftener, with free intervals of months, weeks, and days; several attacks have been observed to recur during one day. In some individuals the attacks are frequent only at times, or they occur during a limited period of life only.

The attack is usually followed by a more or less severe headache, which is sometimes hemicranial, especially when the attack was a hemianopic one. The headache may be on the same or on the opposite side. It has the true character of nervous headache, and leads to nausea and vomiting. Sometimes, however, it is very mild, and the disturbance of vision is only followed by a little nausea and fatigue. * * * * *

These attacks of nervous blindness are often observed in literate men, and generally in individuals who do much mental work; they are probably not more frequent among natural scientists and physicians than among other members of the scientific professions, but have been better observed among them, and been more frequently described on account of their great theoretical importance. Some individuals suffer from this affection all their lives; in others the attacks come at times only, and may then be brought into connection with bodily or mental exhaustion, fatiguing scientific or professional labor, want of sleep, etc. In others a neuropathic disposition is at the base of it. * * * *

Some individuals can suppress an attack by means of a glass of wine or liquor, a cup of tea or coffee, calomel in an aperient dose (when there had been constipation), by dipping the hands into hot water, by slight but often repeated contusions of the head by beating it with the flat of the hand, by means of washing the eyes in cold water, etc. Most patients feel easiest during the attack by keeping as quiet as possible, with their eyes closed, and find the attack passing off in the quickest manner in this way."

From the foregoing remarks of Leber my attack seems to have been a rather typical one of this affection. There is only one point on which we disagree. I have never before nor since this attack of scintillating scotoma been subject to hemicrania; yet my mother was a frequent sufferer from it, and has, as far as I can now understand it, been often attacked by this form of scotoma.

A CASE OF ACUTE LOCALIZED CHOROIDITIS.

By J. Oscroft Tansley, M. D.

Assistant Surgeon to Manhattan Eye and Ear Hospital, New York City.

F. S. æt 19 years. Engineer. Athens. N. Y. sent to me by Dr. Schoonover, August 7, 1881: Says he has always considered himself slightly shortsighted, as he was not able to see objects at long distances as clearly as some of his friends: but never had any trouble with his eyes until one week ago: then came a slight blur over the left eye, with very slight pain. Never had syphilis, nor headache of any serious amount, certainly not recently, and considers himself perfectly healthy.

R. V. $= \frac{20}{XXX}$; w. $- \frac{1}{36}$ c. ax $100° = \frac{20}{XX}$.

L. V. $= \frac{20}{C}$; w. $- \frac{1}{30}$ c. ax $90° = \frac{20}{XXX}$.

He has no blur when using these glasses. Reads $\frac{20}{XX}$. easily and pleasantly, and says he *never saw better.*

His fields of vision—in each eye—without glasses, are both alike and of normal size and shape. Oph. Exam. Right eye normal in every particular. Cannot be sure of the astigmatism. Left eye. Cornea clear; there are two quite large plaques of opaque nerve fibers above and below the disc, which are upon their apices hyperopic $+ \frac{1}{48}$ while the rest of the fundus looks slightly myopic. I cannot make out the astigmatism. The superior and inferior vessels pass directly over these plaques, but they are not hidden excepting at their very exit from the disc. Here they are disguised by a hazy material which is a species of perivasculitis, and which can be traced to the finest ramifications of all the vessels of the eye. The veins are somewhat tortuous, but not markedly congested or enlarged. The macula can be easily seen, and is normal, but about the macula, for an area of which the macula would be the center and the disc the periphery, there is a hazy indistinct appearance which is suspicious, and consists of lights and shades in rows like the furrows of a plowed field, and which also seems to dance about like a play of shadows. Using homatropia this appearance is somewhat modified, yet remains quite marked superiorily, tem-

porally, and inferiorly of the macula; these rows seem to take nearly the direction of the astigmatic axis but not exactly; at one place they pass directly over a vessel, but do not disguise or change its appearance.

The vessels seem to come nearer to the macula than normal, and are slightly tortuous. I cannot think there is anything pathological, but deem the trouble complained of, to be dependent upon the astigmatic error of refraction and which has just become manifest to the patient. Yet, the fundus appearance is suspicious and justifies keeping the case under observation.

The urine is normal to acid and heat test.

August 14, 1881. Patient says that the shadows are slightly more manifest than when last seen.

R. V. = $\frac{20}{XXX}$; with — $\frac{1}{40}$ c. ax. 90° = $\frac{20}{XX}$. L. V. = $\frac{20}{C}$; with — $\frac{1}{0}$ c. ax. 90° = $\frac{20}{XXX}$.

Cannot see as well with — $\frac{1}{30}$ c. which was the strongest accepted upon last visit.

Ophthalmoscopic examination. Almost directly below the macula and a little to the temporal side is a large spot of acute choroiditic exudation which is bulging out into the vitreous; its apex being about + $\frac{1}{48}$, while the surrounding fundus is about — $\frac{1}{24}$. The vessels pass up and over the spot, and are not disguised in the least. It is white and about the size of four discs; it has not invaded the macula. The shadow like appearances about the macula, noticed a week ago, are the same as then. This condition certainly was not present at the last visit, because the macula region was especially and carefully examined: it is possible that the bulging might have been there to some extent and the slight localized hypermetropia have passed unnoticed, but the appearances were surely only what I mentioned in my last notes.

Diagnosis is now of course localized choroiditis; the retina not being much of any affected yet. Put upon inunction of ung. hydrarg. and increasing doses of kalii iodidum.

August 17. L. V. $\frac{20}{CC}$; with — $\frac{1}{20}$ c. ax. 90° = $\frac{20}{XL}$.

Examination shows a lessening in the density of the exudate, but an increase in dissemination; the macula cannot be as easily made out, being a little cloudy; the vessels of this part are be-

coming slightly disguised, particularly the descending temporal artery and vein, which pass along the lower border of the spot, and the retina here is evidently becoming slightly œdematous. There are to be seen to-day the characteristic spots of deposit on the membrana Descemet, of the so-called serous iritis. Increased inunctions and kalii iodidum.

August 19. Not much change in appearance, descending artery is slightly more disguised; also think the macula a little less clear. The Descemetric membrane spots somewhat increased. Several light colored opacities are to be seen in the vitreous with a $+\frac{1}{24}$, $+\frac{1}{16}$ and $+\frac{1}{12}$ in the ophthalmoscope, but with no stronger lens. They are mostly, if not entirely, upon the temporal side.

August 21. L. V. $=\frac{20}{CC}$; w $-\frac{1}{20}$ c. ax. 90°$=\frac{20}{XXX}$ —. The serous iritic spots on cornea are less in number; opacities in vitreous, more diffuse; macula seems clearer and healthier; the white exudate thinner and less *woolly*.

August 23. L. V.$=\frac{20}{C}$; with $-\frac{1}{20}$ c. ax. 90° $=\frac{20}{XXX}$, corneal spots about the same, vitreous also about the same, but the exudate in choroid and serum in retina have become markedly thinner.

He says he still sees as though looking through something dusty but thinks the blur is thinner.

August 26. L. V. $=\frac{20}{L}$; with$-\frac{1}{20}$ c. ax. 90°$=\frac{20}{XXX}+$. Exudate very much thinner; the center of the spot is becoming very white or rather more *clearly* white.

August 28. L. V. $=\frac{20}{C}$; with $-\frac{1}{20}$ c. ax. 90° $=\frac{20}{XX}$—; corneal spots almost gone; the rest about the same as when last seen.

August 31. L. V. $=\frac{20}{C}$; with $-\frac{1}{20}$ c. ax. 90° $=\frac{20}{XX}$—; choroidal exudate much thinner and clearer; small bright spot of glistening cholesterine over the descending temporal artery which was not present previously.

September 7. L. V. $=\frac{20}{LXX}$ with$-\frac{1}{30}$ c. ax. 90° $=\frac{20}{XX}$ — will not accept the $-\frac{1}{20}$ c used previously. The macula looks much clearer, and the exudate is disappearing but not so rapidly as previously. No corneal spots to be seen.

Sept. 17. L. V.$=\frac{20}{XXX}$ —; with$-\frac{1}{36}$ c. ax. 90° $\frac{20}{XX}$. Says there seems to be a net work or spider web before the eye.

The cornea is absolutely clear, as is also the vitreous; retina very much better. Told to continue as before.

Sept. 23. L. V. $=\frac{20}{XL}$; with $-\frac{1}{36}$ c. ax. 90° $=\frac{20}{XX}$ +.

Everything looks nicely; ordered to stop inunction and the solution of kalii iodidum and take syrup. ferri iodidi ℥i; with kalii iodidi gr. vj. t. d.

Sept. 29. L. V. $=\frac{20}{XXX}$; with $-\frac{1}{48}$ c. ax. 90° $=\frac{20}{XX}$; cannot accept any stronger glass than $-\frac{1}{48}$ c. Has now no cloud, dimness or opacity of vision with it without glasses. Cornea and vitreous perfectly clear; retina very much improved; there are several very bright and glistening spots of cholesterine in the retina just below the macula which have not been visible before. Told to continue the syr. fer. iodidi. c. kal. iodid. t. d. for three weeks and return.

Nov. 1, '81. R. V. $=\frac{20}{XXX}$, with $-\frac{1}{36}$ c. ax. 100 $=\frac{20}{XX}$.
L. V. $=\frac{20}{XX}$. E. *will not accept any glass.*

The macula is normal and healthy; the spot of atrophic choroid is clear and white; the vessels passing over the spot are clear, healthy and unaffected; retina shows nothing abnormal and *no* scotoma can be found.

There are several spots of cholesterine, as before mentioned, but the active process has passed away.

Told to take internally kal. iodidum gr. viij. and strychn. sulph. gr. $\frac{1}{30}$ t. d. for six weeks or two months, and to see me should he have any trouble.

This case is interesting because of the astigmatism being present upon the first examination, and the pathological condition not being recognized, although examined carefully; but more particularly because the astigmatism increased gradually, —glasses always giving good vision—afterwards became less, and, finally, entirely passed away.

The fact of the astigmatism being myopic is also interesting; it would naturally be expected that it would be hypermetropic. It was probably dependent upon a disarrangement of the layer of rods and cones rather than an alteration in the form of the internal surface of the retina.

I regret that I did not try the refraction when under atropine, for it is possible that the astigmatism was hyperopic, and a spasm

of accommodation converted it into a myopic one. My reason for not using atropine was that I feared the effect of light, deeming one of the causes of the trouble to have been the bright light caused by opening the furnace doors of the boilers which were under his care.

THE PRESCRIBING OF CYLINDRICAL LENSES.

BY EDWARD JACKSON, M. D.

Chief of the Eye Clinic in the Philadelphia Polyclinic

Cylindrical lenses can only correct what is known as regular astigmatism. With regular astigmatism there is always present some irregular astigmatism which we have no means of correcting. Bearing this in mind, the first principle governing the prescribing of cylindrical lenses is:

One cylindrical lens, of the proper strength, placed with its axis in the right direction, and with the proper spherical lens, will correct any case of astigmatism, in so far as it is capable of correction by cylindrical lenses.

This rests upon the laws which govern the action of cylindrical and sphero-cylindrical lenses, and is susceptible of rigid mathematical demonstration. It was clearly understood fifty years ago by the mathematician and astronomer Airy, when he ordered a sphero-cylindrical lens for the correction of his own compound myopic astigmatism.

When, in the use of trial-lenses, the patient seems to see better through a second cylinder with its axis placed obliquely, as compared with the axis of the cylinder already before the eye, it is simply to be taken as evidence, that the cylinder first selected was not of the proper strength, or its axis turned in the right direction, and perhaps that the right spherical lens had not been combined with it.

In reading the following paragraphs, bear in mind the distinction between meridian and axis, the latter being perpendicular to the plane of the former. The principal meridians of refraction are, for regular astigmatism, always perpendicular to one another. They are often spoken of as the principal meridians of the cornea, but this involves the unwarranted assumption that the total astigmatism is identical with the corneal astigmatism.

Having determined the degree of ametropia in each of the

principal meridians of refraction, the proper correction is thus arrived at:

a. *Make the spherical plus or minus as the meridian of least ametropia requires a plus or minus correction.*

b. *Make the spherical just strong enough to correct the meridian of least ametropia.*

c. *Make the cylindrical plus or minus, as the meridian of greatest ametropia requires a plus or minus correction.*

d. *Make the refractive power of the cylindrical equal to the difference between the refractive powers of the principal meridians.*

e. *Place the cylindrical so that its axis corresponds with the axis of greatest ametropia, its meridian of greatest curvature corresponding to the meridian of greatest ametropia.*

For illustration take the following supposititious cases:

Compound hypermetropic astigmatism. In one principal meridian, at 90° (axis 180°), H = 1. D; in the other principal meridian, at 180° (axis 90°), H = 4.D. The correction for H is plus. Hence, (a) sign of spherical +; strength of spherical (b) =1. D, or the correction for the meridian of least ametropia. Sign of cylindrical (c) that of correction for greatest ametropia, +. Strength of cylindrical (d) = 4. — 1. = 3. D. Direction for the axis of cylindrical (e) that for the *axis* of greatest ametropia, that is 90°. Hence, the prescription + 1. Sph. ⌒ + 3. cy. axis 90°.

Simple hypermetropic astigmatism. Meridian of 90° (axis 180°) emmetropic or H = 0. Meridian of 180° (axis 90°) H = 3. The spherical becomes zero. Sign of cylindrical +; strength 3 — 0= 3; axis, that of greatest ametropia, 90°. Hence + 3 cy. axis 90°.

Mixed astimatism with predominant hypermetropia. Meridian of 90° (axis 180°) myopia =1. Meridian of 180° (axis 90° hypermetropia=2. The 90° meridian (180° axis) is of course that of least ametropia, and the 180° meridian (90° axis) that of greatest ametropia. Hence, spherical, sign (correction for M) minus, strength 1.D. Cylindrical, sign (correction for H) plus; strength, (the ametropia in the two meridians being of opposite kinds, one refracting 1.D too strongly, the other 2. D too weakly,

the difference becomes the sum of these) 1 + 2 = 3; axis, that of greatest ametropia, 90°. Thus we get — 1 sph. ⌒ + 3 cy. axis 90°.

Mixed astigmatism with predominant myopia. Meridian of 90° (axis 180°) M = 2. Meridian 180° (axis 90°) H = 1. The 90° meridian being now most ametropic, the 180° meridian least ametropic, we have spherical sign +, strength 1, cylindrical sign — strength 2 + 1 = 3, and axis, that of greatest ametropia, or 180° = + 1 sph. ⌒ — 3 cy. axis 180°.

Simple myopic astigmatism. Meridian 90° (axis 180) M = 3. Meridian 180 (axis 90°) emmetropic, or M = 0. Here again the spherical becomes zero and we get — 3 cy. axis 180°.

Compound myopic astigmatism. Meridian 90°(axis 180°)M= 4. Meridian 180° (axis 90°) M = 1. Here we get by application of the rules, —1 sph. ⌒ — 3 cy. axis 180°.

Now each of the lenses as determined above has an optical equivalent in the shape of a sphero-cylindrical lens, and all except those for simple astigmatism have optical equivalents in crossed cylinders thus:

For + 1 s. ⌒ + 3 cy. ax. 90°, the equivalent is + 4 s ⌒ — 3 cy. ax. 180°; or, = + 1 cy. ax. 180° ⌒ + 4 cy. ax. 90.

For + 3 cy. axis 90°, the equivalent is + 3 s ⌒ — 3 cy. ax. 180°.

For — 1 s ⌒ + 3 cy. ax. 90°, the equivalent is + 2 s ⌒ —3 cy. ax. 180°; or, — 1 cy. ax. 180° ⌒ + 2 cy. ax. 90°.

For + 1 s ⌒ — 3 cy. ax. 180°, the equivalent is — 2 s ⌒ + 3 cy. ax. 90°; or, + 1 cy. ax. 90° ⌒ — 2 cy. ax. 180°.

For — 3 cy. axis 180°, the equivalent is — 3 ⌒ + 3 cy. axis 90°.

For — 1 s ⌒ —3 cy. ax. 180°, the equivalent is—4 s ⌒ + 3 cy. ax 90°; or, — 1 cy. ax. 90° ⌒ — 4 cy. ax. 180.

These have been spoken of as exact optical equivalents, and so they would be if we were dealing with lenses infinitely thin, and absolutely free from aberration. But as a matter of fact we have to employ lenses of appreciable thickness and exhibiting the defects of aberration, both chromatic and so-called spherical, which equally affects cylinders whose normal section is a circle.

When the spherical correction is ground on one side of the glass and the cylindrical correction on the other, there occurs distortion and narrowing in one direction of the field of the lens, which is greater for crossed cylinders than sphero-cylinders, and increases with the thickness of the glass. Aberrations increase with the curvature of the surfaces, as does also the necessary thickness of the glass. A careful study of the matter will show, that the above rule always guides to the selection of the sphero-cylinder having surfaces of the least curvature, and therefore being the least affected by aberration and distortion of the field. Moreover, the glass so selected is the lightest, and is most read ily ground with accuracy, and therefore the cheapest. On all accounts it is the best. In the January number of this Journal (p. 14), Dr. H. Culbertson has urged the use of negative cylinders for distant, and positive cylinders for near vision. He says: "That we have a choice of cylinders in the correction of ametropia, is well known, Thus in a given case of C O. H. A. = + D 1.0 s. ⌒ = D 0.5, axis (?) 180°, we may employ + D 1.5 s. ⌒ — D 0.5 cy. axis 180°; or, + D 1.5 s. ⌒ + 0.5 cy. ax. 90°."

That we have a choice among two or three equivalents, has been indicated; and the rule given to guide us in making the choice. By it is chosen the best combination for vision at any distance. Dr. C. finds one of the combinations to answer better for distance, and the other for near, simply because his combinations are not optical equivalents; + 1.5 s. ⌒ — 0.5 cy. axis 180° is not the equivalent of + 1.5 s. ⌒ + 0.5 cy. ax. 90°. The latter has, in every meridian, 0.5 D. more of refractive power than the former. If the former corrects the ametropia, the latter over-corrects it. If the latter is the proper correction, the former is insufficient. Of course the patient rejects an over-correction for distant vision, while for near he sees better with it. In such a case, he chooses the combination of lesser refractive powers for distant vision, not because it happens to be unscientifically arranged with a concave cylinder, but because it is the weaker lens; and he takes the other for near, not because it has a convex cylinder, but because it makes a stronger lens. Had real equivalents been compared as, + 1.5 s. ⌒ — 0.5 cy. axis 180°, with + 1. s. ⌒ + 0.5 cy. axis 90°; with glasses so

weak as these most patients would notice no difference. Still we know that the latter, chosen by the rule, is slightly better, because thinner and less affected by aberration. The same criticism applies to the other cases supposed to illustrate these different applications for positive and negative cylindrics in the "*correction of ametropia.*"

Of course we are constantly ordering lenses which but partially correct, or over-correct the ametropia present. But this is done for a special purpose, not with any idea that it is the correcting lens that is being ordered.

For instance in the case of simple myopic astigmatism; suppose the patient's accommodation lost, and that he wants a glass to read with at 13 inches. The myopic meridian now has the proper refractive power, while for this purpose the emmetropic meridian requires + 3. D. Taking the rule; and for correction substituting required change of refractive power; and for ametropia the difference between existent and desired refractive power, we find 90° meridian (180° axis has the proper refractive power; 180° meridian (90° axis) requires 3. D. added to refractive power. Spherical zero. Cylindrical sign +, for, in axis of greatest required change, refractive power must be added, strength 3—0=3. Axis that of greatest required change, 90°; hence:

For near work, + 3 cy., axis 90°.

TRANSLATION.

The following extracts from an article, *The etiology of cataract. Juvenile cataracts in workingmen employed in glass factories. By D. Meyerhoefer. Zehender's Monstabl. f. Augenhlk. Februar* 1886, seem to be of especial interest, as the observations of Dr. Meyerhoefer throw a great deal of light on the etiology of certain forms of cataract. After having stated that he had within two years, seen four juvenile individuals with cataract, all of whom were employed in glass factories, and that this gave him the idea, that this was more than an accidental occurrence, he says:

* * * The results of my examination of 506 individuals employed in glass factories are worthy of consideration to the highest degree.

Of these 506 men 134 were less than 20 years of age, 212 were between 20 and 30, 96 between 30 and 40, 45 between 40 and 50, 16 between 50 and 60, 2 between 60 and 70 and 1 was more than 80 years of age. The youngest was 15, the oldest 81 years old.

My examinations show in the most startling manner, how correct was the assumption, which prompted me to make them, as I found dimness of the crystalline lens in fifty-nine individuals, i. e., in 11. 6 per cent. of all the cases.

This result is certainly a startling one, and is the more so when we consider the comparative age of the individuals affected, since we find a remarkable excess of the juvenile cataracts.

Considering the difficulty in giving a distinct limit for what we may call a juvenile cataract, I think we may put under that head all cataracts before the 40th year of life is reached. We then find that among 442 workingmen under 40 years forty-two individuals, i. e. 9. 5 per cent. showed premature dimness of the lens. Of these six were under 20 years, twenty between 20 and 30 years, and sixteen between 30 and 40 years old.

Of the sixty-four workingmen who were older than 40 years 17, i. e. 26. 5 per cent., showed a dimness of the lens. * * *

* * * From the foregoing tabulated statement it is plain that the juvenile cataracts I found among the glass-makers showed the same characteristic forms, as do juvenile cataracts in other individuals. The one point only cannot help being noticed, namely, that *the left eye* was found to be affected much more frequently than the right.

I should, furthermore, state here that in the affected individuals no diseases of the fundus (which might have accompanied or caused the formation of the cataract) could be found with the ophthalmoscope.

The frequency of the occurrence of cataract among the glass-makers can hardly be considered to be accidental. On the contrary, we are forced to assume most decidedly that there must exist a common cause. The question is now, of what nature is this cause. * * *

* * * In only eight of the cases have I been able to apply the sugar test. * * * In these cases no trace of sugar was found in the urine. * * *

* * * It, therefore, only remains to assume that noxious influences which especially lead to the formation of premature cataract, are inherent to the manufacture of glass. Every one, who has had an opportunity to become acquainted with the character of this work, can easily comprehend that glass is manufactured under such circumstances, that the organism of the workingmen employed near the fire (and those alone are here under consideration) must be influenced in a grave manner. * * *

* * * The men usually begin the work as glass-makers when 16 years old, and from that day forth their only occupation is with the hot, fluid mass in the immediate neighborhood of the melting-furnace. They work from ten to twelve hours daily and without interruption until the furnace needs repair and the fire must be extinguished. Thus the work is kept up without a day's rest, Sundays and week-days, for from forty to forty-five weeks; then they have a rest, which usually lasts for about eight weeks.

The temperature in which these glass-makers have to stay for half a day is really "infernal." The thermometer at the distance at which the workman has to keep his face, especially its

left half, towards the open fire (though for a short period only each time when he dips out the glass, but at short intervals and very often), showed after about ten minutes a temperature of 65° Celsius.

Most of the glass-makers show the effects of this enormous heat plainly in their faces. The heat usually causes the skin of the face to be burned slightly, and this is shown by a reddish-brown color of the skin: in some cases even the skin is dry and like leather. In some glass-makers the heat will cause inflammatory processes which lie deeper in the tissue of the skin and which result in the formation of scars. In one case this formation of scar-tissue had caused ectropium of the lower lid on the left side. This case showed very plainly the intensity of the heat in which the glass-makers have to work. Besides the scar-tissue in the skin of the cheek and the resulting ectropium, there existed on both corneæ whitish, cicatricial formations which could only be due to former losses of substance. Neither the patient nor his mother knew anything of a former inflammatory process and even emphatically denied its former occurrence, yet, these scars of the cornea could only be explained as consequences of the work near the fire, as a kind of drying up and burning of the superficial layers of the cornea.

The second result of the enormous heat in which the glass-makers are at work is the excessive increase of their transpiration. This is so great that the sweat actually runs from them. They do, of course, not get accustomed to this, since the transpiration is the necessary correcting agent against the terrible heat, and without it the surface of the workman's body would finally have to be burned. * * *

* * * I want here to state that the earnings of glass-makers are unusually high, and that in this way they are enabled to take the nourishment which is adapted to their work. Their looks, therefore, are not in the least unhealthy. * * * The premature formation of cataract among them is then not due to marasmus.

In these two factors, namely, the *enormous heat* of the open furnace and the *profuse secretion of sweat* due to it, by which the trade of the glass-workers is distinguished from others, we

must seek the combined causes or in one of the two *the* cause of the premature formation of cataract in these workmen. * * * * * * The exclusive causation was not to be seen in the enormous heat alone, since besides nineteen cases of cataract in both eyes, in seven cases the *right* eye alone was the affected one. [Dr. Meyerhoefer does not seem to have taken into consideration that this might be explained by the fact that these latter seven workmen were, perhaps, left-handed, which would explain the discrepancy.—EDITOR.]

Another explanation being wanting, I was forced to accept as a second cause, and one which, perhaps, would help at the same time and to a higher degree in the formation of the premature cataract, the other factor, which may be considered as characteristic of the glass-makers work, namely the continuous hypersecretions of sweat, the continued loss of water to which the body is subjected during their work.

It is just on this point that it seems to me my observations call for more than a simply casuistic interest, since they may be apt to answer the hitherto open question as to the formation of the *diabetic cataract.*

Such a comparison between the glass-maker's and the diabetic cataract seems to me to be obvious, the *tertium comparationis* being the enormous and continued loss of water.

It will probably have the same effect, whether a diabetic patient loses an excessive amount of water through polyuria, or a glass-maker loses it through the excessive secretion of sweat, the effect being a loss of water, a drying up, so to speak, of all the tissues of the body. That such a loss of water can cause the formation of cataract is proven by the experiments of Kunde and his successors. * * *

CORRESPONDENCE.

DUNKIRK, N. Y., FEB. 27, 1886.

Mr. Editor:—I read with interest but with regret Dr. Coggin's letter advocating the adoption of a 36 inch lens as the standard equivalent of one dioptre, and making the remarkable statement "that a + 36 American lens is nearer the standard dioptre (37 French inches) than is a + 40."

As I understand the matter, a + 1 D is a lens whose principal focus (i. e. focus for parallel rays) is equal to one metre; now one metre is equal to 36.94 + French inches and to 39. 37 + English or American inches. Hence Dr. Coggin's statmement is just the reverse of the facts, and the correct statement is "that a + 40 American lens is nearer to the standard dioptre (37 French inches) than is a + 36", and is indeed a very close approximation.

A + 36 *French* is indeed nearer to the standard dioptre than + 40 French, providing the French numbering refers to the focal power of the lens; but as the old numbering of lenses was based, not on the focal power but on their radii of curvature, and it was merely a happy chance that the radius of curvature corresponded very closely with the focal length when the lens was double and equally convex and the glass of which it was made had an index of refraction of 1.5. under such a system two lenses might be numbered alike, and correctly so, and yet being made of different qualities of glass with different indices of refraction would differ in power. In practice this will often be found to be the case, spectacles of the same number, especially among the cheaper imported goods, varying considerably in power.

It is to be hoped that the dioptric system will soon be adopted in entirety, and spectacle lenses ground upon it. Then a + 1 D will have a focal length of one metre equal to 39.37 + American inches, and till then we had better adopt for our approximation, 40 American inches, which varies from the correct amount by less than two per cent., than 36 which is very nearly ten per cent. out of the way.

36 has the advantage over 40 in being a greater common multiple, but is widely erroneous while 40, which is a sufficiently great common multiple for all practical purposes, is so nearly correct, that the error resulting from its adoption is absolutely of no practical importance. Yours respectfully,

GEO. E. BLACKHAM.